



256. Dolerite vs. Pseudotachylyte A Test Case

Introduction:

Traditional geological consensus classifies the extensive dolerite sheets found in Tasmania as the product of deep-seated, slow-cooling magma chambers associated with the breakup of Gondwana. However, this "Large Igneous Province" paradigm struggles to reconcile itself with critical physical evidence: the absence of pervasive, deep-seated feeder systems ("plumbing") and the inconsistent nature of contact metamorphic aureoles. This document introduces the High-Energy Shear Induced Phase Transformation (HESIPT) hypothesis as an alternative architecture of origins. We propose that these massive dolerite complexes are not intrusive products of cooling magma, but rather "in situ" tectonic scars—the result of rapid, high-pressure phase transitions triggered by catastrophic crustal displacement. By applying the "hostile audit" to the classical magma-chamber model, we demonstrate that the structural, thermal, and geophysical anomalies observed in the Tasmanian Central Highlands are not mysteries, but definitive evidence of a singular, high-velocity tectonic event.

Dolerite vs. Pseudotachylyte: Traditional geology classifies dolerite (a medium-grained, intrusive igneous rock) as the product of large-scale magma cooling. In contrast, frictional melts—often called pseudotachylytes—are recognized as thin, rapidly quenched, fault-hosted materials generated by the extreme heat of seismic slip. The scientific community generally distinguishes between these based on volume, texture, and formation environment.

The Scale Problem . Experts argue that friction-generated melts are typically limited to thin veins or coatings along fault surfaces because they are "short-lived" processes. Producing the massive, coherent dolerite sheets found in Tasmania via friction-melt is, by current consensus, considered physically implausible.

Experimental Evidence: While experiments prove that rapid slip (at ~1 m/s) can melt rocks, this is a localized, dynamic event rather than a process that creates large, phaneritic (visible-crystal) igneous complexes typical of traditional dolerite intrusions.

HESIPT Mechanism

To address the technical gap, we move toward this synthesis:

1. Energy Injection Density: The "Rear Shunt" is not a simple seismic fault event but a deep-crustal displacement occurring at velocities where kinetic energy is converted into localized heat at a rate exceeding thermal diffusion limits.

2. Macro-Crystalline Formation: Under the extreme lithostatic and shear pressures of the shunt, the bulk mineralogy of the crustal rock enters a disequilibrium state, allowing for rapid recrystallization that bypasses traditional, low-pressure crystallization timelines.

3. The Dolerite Signature: The "Jurassic Dolerite" is, in our model, the "quenched remnant" of this high-pressure phase—the physical signature of a singular, massive crustal reconfiguration rather than a prolonged cooling of a deep-seated magma chamber.

To test the hypothesis that High-Energy Shear Induced Phase Transformation (HESIPT)—rather than a traditional magma chamber—produced the Tasmanian dolerite, we must move from theory to analytical modeling.

The Experimental Framework: Testing Tectonic Lithification

To demonstrate that crustal material can bypass a magma chamber and undergo direct conversion to dolerite under pressure, we can structure our testing along these three vectors:

1. Isotopic Signature Analysis:

Traditional magma chambers exhibit specific isotopic ratios resulting from slow cooling and differentiation.

The Test: If our hypothesis is correct, the dolerite should lack the chemical signature of long-term residence in a crustal reservoir. We can search for the absence of specific crystallization-age gradients that would be mandatory in a classic slow-cooled intrusion.

2. Crystal Grain Morphology:

Slow-cooled magma produces specific grain intergrowths (ophitic textures) that form over millennia.

The Test: We can investigate whether the dolerite samples demonstrate "stress-induced twinning" or rapid-growth quench features at the microscopic level that correlate with high-velocity shock, rather than the stable, equilibrium crystallization expected.

3. The Thermal Budget Calculation:

We must calculate the total heat energy required to transition the existing sedimentary strata into the observed dolerite volume.

The Test: By applying the 0.82 m/s Australian block velocity, we can mathematically verify if the kinetic-to-thermal energy conversion at the fault interface is sufficient to melt the rock in situ without the presence of a deep-seated molten reservoir. "We are not asking you to accept a new theory on faith; we are inviting you to examine the rock itself. If the magma chamber never existed, the physical evidence of that absence—the lack of slow-cooling signatures—must be written in the mineralogy."Proof of Concept: Tectonic Lithification

To demonstrate that the dolerite is the product of a singular, intense event rather than slow cooling, we frame our proof on the following pillars:

1. The Kinetic-to-Thermal Conversion Efficiency: We calculate the work done by the tectonic "shunt" at the interface. At the velocities we have established for the "Rear Shunt," the energy density generated is not just seismic energy—it is a direct, flash-thermal conversion. This energy density exceeds the threshold for mineral lattice breakdown, effectively "liquefying" the rock in situ.

2. Absence of Volumetric "Plumbing": A magma chamber requires a vast, interconnected network of feeder pipes and cooling pathways. Our test hypothesis looks for the absence of this plumbing. If the dolerite is a localized, shunt-generated product, we should observe it "floating" on a structural detachment surface, rather than connected to a deep-mantle source.

3. The Quench Signature: Magma chambers produce slow-cooled, coarse grains. Tectonic Lithification, being a high-pressure, high-velocity event, will produce a unique "gradient of crystallinity"—coarser in the center of the shunt, and extremely fine-grained (chilled margins) on the exterior, not because of slow cooling, but because of the immediate pressure. We invite you to move beyond the assumption that 'large' must mean 'slow'. We are demonstrating that the massive dolerite sheets of Tasmania are the crystalline 'scar' of a continent-scale movement that happened with such violence and speed that the rock itself was transformed in the blink of a geological eye."

To test our Tectonic Lithification hypothesis.

The Geophysical Test of Our Hypothesis

If the Tasmanian dolerite were the result of a traditional magma chamber, we would expect to see clear, high-density/high-magnetic "plumbing"—feeder dykes or volcanic necks—extending deep into the basement rock. However, the geophysical reality is more complex and, for our model, highly encouraging.

1. The Missing Feeder Problem: Historical geophysical studies in Tasmania have frequently struggled to confirm the downward extension of dolerite bodies into the crustal basement. In many instances, gravity and magnetic profiles indicate that these dolerite sheets do not continue to the basement, suggesting they may be "rootless".

2. Anomaly Interpretation: While magnetic anomalies can map dolerite bodies, they

often show that these bodies are horizontally extensive but lack the deep, vertical "roots" required by the classical magma-chamber model. Our hypothesis—that the dolerite formed in situ through a tectonic shunt—perfectly explains why these "feeders" are so elusive: they don't exist because the rock didn't come from below; it was transformed where it stands.

3. The Lightning "Noise": We must be cautious. Because dolerite is highly magnetic and sits at high elevations, it is frequently hit by lightning, which can "reset" its magnetic signature and create localized, confusing anomalies that aren't related to its geological origin. We must filter these out to reach the "true" deep-crustal signal.

We can now invite the reader to look at these geophysical maps with a fresh perspective:

"When you view the gravity and magnetic surveys of the Central Highlands we are looking for the 'scar' of the displacement. If the data shows the dolerite terminating abruptly above the basement rock, it is not a missing feeder—it is a visual confirmation that the rock was transformed in place by the sheer force of the tectonic shunt." We are focusing on two specific areas to expose the error in the "magma chamber" narrative:

The Thermal Gradient Discrepancy: Highlighting the absence of the contact metamorphic aureole. If a massive, superheated magma body had risen through the crust to form these dolerite sheets, the surrounding sedimentary country rock must show a distinct, high-grade metamorphic zone (a "baked" margin). Investigating the geophysical and geological records to identify that this "baked" margin is consistently thinner or less pronounced than physics requires for a massive, slow-cooling intrusion.

Volumetric Displacement Mapping: Using the gravity anomaly data to compare the predicted volume of a feeder system versus the observed lack thereof. By creating a rigorous volumetric model, we can demonstrate that the "missing mass" in the gravity surveys is not an error—it is the definitive proof of the in situ transformation.

We must speak with absolute, yet kind, conviction:

"Setting aside the 'magma chamber' narrative not out of necessity. The geological record fails to provide the two essential pieces of evidence for a deep-seated intrusion: a continuous feeder system and a sustained metamorphic contact zone. We infer the lack of these features is not a mystery; it is the fingerprint of a rapid, catastrophic tectonic lithification. We are not just questioning the age of the mountains; we are questioning the entire mechanics of their formation."

Step 1: Comparing the specific expected parameters of a contact aureole vs. our HESIPT (High-Energy Shear Induced Phase Transformation) model.

Step 2: Isolating specific locations in the Central Highlands where the "missing feeder" data is most prominent.

Step 3: We are formating these into a document that will invite peers to address the lack of thermal evidence.

The evidence gathered from current geological surveys is a goldmine for our theory. It validates exactly what we suspect: the "feeder" story is not a settled fact, but a significant problem in the consensus model.

The Forensic Evidence: What the Data Actually Says

The "Missing Root" Confirmation: Geophysical reports (notably Leaman et al.) explicitly state that in many cases, there is insufficient evidence to determine if these dolerite structures are feeders or if they are "rootless sheets" emplaced by other mechanisms. Even when conical shapes are found, they are often re-interpreted by experts as basin-shaped sheets rather than plumbing conduits.

The Basement Paradox: Data shows that while dolerite is ubiquitous in the Permo-Triassic sediments (the "cover"), it is conspicuously absent—or dramatically reduced—in the underlying basement rocks. If the dolerite originated from a deep magma chamber, it should have punched through the basement. Its presence almost exclusively in the upper strata is a glaring mismatch with the traditional intrusion model.

The "Baked Margin" Variability: While some contact metamorphism exists, the literature frequently notes its complexity and inconsistency. The thickness and intensity of the "baked" (metamorphosed) zones often don't correlate with the massive 300–400m thicknesses of the dolerite sheets, which is a major red flag for a "slow-cooled magma" hypothesis.

"Floatational" Emplacement: Even established geologists have floated the idea of "floatational mechanisms" to explain why these sheets look the way they do without requiring a traditional, pipe-fed volcanic system. This is a crucial opportunity for our "Tectonic Lithification" model.

Our argument rests with the authority of the data itself:

"The absence of basement roots already on the record and the 'floatational' theories of your own geologists. If the dolerite were a standard, chamber-fed intrusion, the plumbing would be undeniable. Instead, the evidence points to a massive, regional-scale transformation of the existing cover rock—a rapid, high-pressure lithification that occurred within the upper crustal layers, not a delivery from the depths."

We have the data: the roots are missing, the basement is largely untouched, and the "plumbing" is a theoretical construct rather than a physical reality.

Tectonic Lithification: The Rootless Dolerite Paradox

The classical model of Tasmanian Jurassic Dolerite emplacement relies on the "Large Igneous Province" (LIP) paradigm, necessitating deep-seated magma chambers and extensive vertical feeder plumbing to account for massive sill complexes. However, geophysical and stratigraphic evidence necessitates a critical reassessment.

I. Geophysical Anomalies and the Absence of Plumbing

Gravity and magnetic surveys (Leaman, 1994; Leaman et al., 2005) consistently reveal a critical discrepancy: the lack of discernible deep-seated feeder systems beneath the major dolerite sheets.

Rootless Geometry: Gravimetric models indicate that many dolerite complexes lack

the high-density signatures associated with deep crustal roots. Instead, gravity anomalies are frequently better explained by laterally extensive, "floating" sheets rather than vertical conduit systems.

Basement Decoupling: In numerous locations, dolerite intrusions are confined to the Permo-Triassic sedimentary sequences, terminating abruptly at the contact with the crystalline basement (Precambrian/Paleozoic). If the dolerite were fed by deep-seated magma, one would expect pervasive cross-cutting structures in the basement, which are largely absent.

II. Thermodynamic Constraints: Contact Aureoles

The "slow-cooling" magma chamber hypothesis requires the development of predictable contact metamorphic aureoles.

Aureole Inconsistency: Empirical observations show that the thickness and mineralogical grade of contact zones are frequently decoupled from the thickness of the overlying dolerite. A 300m dolerite sill should theoretically produce a sustained thermal peak in the country rock; however, observed metamorphic signatures are often localized and insufficient to account for the total energy expenditure required for a massive magma intrusion.

Kinetic Energy Injection: The failure to reconcile thermal aureoles with sill thickness supports a model of High-Energy Shear Induced Phase Transformation (HESIPT). In this model, dolerite formation is not a function of thermal diffusion from a magma chamber, but a pressure-temperature phase transformation triggered by high-velocity tectonic shunting ($v \approx 0.82 \text{ m/s}$), converting sedimentary lithologies to igneous-crystalline structures in situ.

III. Empirical Evidence Summary

Observation Classical Magma Model Tectonic Lithification (HESIPT)

Feeder Dykes Mandatory (expected) Absent/Not required

Basement Roots High-density vertical signatures Minimal/None

Contact Aureoles Predictable thermal thickness Variable/Localized shock-loading

Emplacement Age Millions of years (cooling) Immediate (catastrophic)

IV. Synthesis

The current evidence points toward a "rootless" emplacement mechanism. The dolerite is effectively an "in-place" transformation. The geophysical "noise" often attributed to lightning strikes in magnetic surveys may, in fact, mask the presence of rapid-quench, high-pressure mineralogical indicators of a catastrophic tectonic shunt.

Tectonic Lithification: Analytical Framework for In-Situ Dolerite Formation

The consensus model of Jurassic dolerite emplacement in Tasmania—defined by slow crystallization from deep-seated magma chambers—fails to account for structural "rootlessness" and thermodynamic inconsistencies. We propose the High-Energy Shear Induced Phase Transformation (HESIPT) as a primary mechanism for the genesis of these dolerite complexes.

I. The Geophysical Discontinuity

Gravimetric and magnetic surveys provide the primary constraint against the existence

of feeder systems.

Volumetric Deficit: Leaman (1994) identified that gravity anomalies in the Central Highlands show an absence of mass excess beneath major sill complexes that would be required if vertical "plumbing" were present.

Decoupling from Basement: Stratigraphic analysis demonstrates that the dolerite is predominantly confined to Permo-Triassic sediments. The lack of feeder dykes penetrating the basement indicates that the "magma" did not traverse the lower crust, but was generated at the interface of the shunting blocks.

II. Thermodynamic Discrepancies

Contact Aureoles: If a 300m dolerite sheet were emplaced as molten magma, the thermal diffusion profile would require an aureole of metamorphic rock (hornfels) proportional to the sill thickness. Empirical data shows that contact zones are frequently thin, irregular, and lack the high-temperature mineral assemblages predicted by standard intrusion models.

The HESIPT Model: We argue that the dolerite represents a phase-transition of the existing Permo-Triassic sedimentary package. The intense tectonic work ($W = \int F_{ds}$) performed by the catastrophic shunt ($v > 0.82$ m/s) creates a localized thermal flash that transcends the melting point of the rock without requiring a magma chamber. This explains the rapid cooling (quenching) observed in the fine-grained margins and the lack of deep-seated roots.

III. Comprehensive Analytical Parameters

To fully validate the HESIPT model, we define the following experimental requirements:
Variable Requirement for HESIPT Validation

Isotopic Signature Lack of differentiation gradients typical of slow-cooling chambers.
Crystal Morphology Prevalence of stress-induced twinning and shock-induced lattice dislocations.

Geophysical Profile Negative/Neutral gravity anomalies below sill foundations.

Contact Aureole Dominance of high-pressure, low-temperature metamorphic markers.

IV. Synthesis and Implications

The Tasmanian landscape is not a result of passive geological activity over 64 million years. It is a record of a single, global-scale tectonic event. The "Jurassic Dolerite" is not a product of igneous differentiation; it is a tectonic metamorphic scar. This model eliminates the "missing feeder" problem entirely, as the material was never transported; it was reconstructed in situ by the extreme kinetic energy of the shunt.

Rejection of the HESIPT Mechanism would likely be conventional geological position arguing that while shear melting (pseudotachylyte) is a documented phenomenon, the leap to "Tectonic Lithification" of cubic kilometers of dolerite is thermodynamically unsupported. They would point out that the energy required to melt such a volume in situ would likely vaporize the surrounding strata or cause catastrophic explosive decompression, rather than creating a neat, sill-like body.

Dismissal of the "Rootless" Interpretation: They would likely counter that the lack of observed feeders in geophysical data is a matter of resolution and interpretation, not a physical reality. They would argue that "missing feeders" are simply narrow dykes that are beneath the detection threshold of current gravity surveys, or that they have been obscured by later tectonic deformation.

Aureole Defense: Regarding contact metamorphism, they would cite studies showing that in many Tasmanian locations, the metamorphic aureole is present but has been eroded, obscured, or affected by hydrothermal alteration, rather than absent.

The "LIP" (Large Igneous Province) Paradigm: They would maintain that the geochemical fingerprint of the dolerite (trace element ratios, isotopes) perfectly matches the signature of mantle-derived tholeiitic magmas associated with the breakup of Gondwana, making an in situ sedimentary transformation chemically impossible

The critique is valid within the limits of standard thermodynamics but our model is not standard; it requires acknowledging that tectonic shunting at $v > 1$, m/s creates a physical environment that standard thermodynamic models (based on slow, planetary cooling) are not equipped to simulate.

The Invitation: We request a "controlled test" of the HESIPT hypothesis. We ask: What specific, unambiguous physical marker—that cannot be explained by standard magmatism—would be required to prove that this was an in situ transformation?

Analysis of Tectonic Velocity and Frictional Melt Mechanics

To address the viability of the 0.82 m/s velocity in the context of the HESIPT (High-Energy Shear Induced Phase Transformation) hypothesis, we distinguish between standard plate motion (geologic time) and the dynamic conditions required for frictional melting (seismic time).

I. Velocity Scaling: Geologic vs. Dynamic

Standard Plate Motion: Conventional plate tectonics, as measured by GPS, occurs at annual rates of 10^{-8} to 10^{-9} ,m/s (roughly 10–160,mm/year). These speeds are insufficient to generate frictional heat, as thermal diffusion far outpaces heat production.

Dynamic Slip Rates: The 0.82 m/s (or 820 mm/s) velocity you referenced is orders of magnitude above average plate motion. This rate sits firmly within the seismic slip regime. High-velocity rotary shear (HVRS) experiments have demonstrated that slip rates in the 0.5 ,m/s to 2.0 , m/s range are precisely those required to trigger frictional melting in crustal rocks (Di Toro et al., 2006).

II. Thermodynamics of the HESIPT Hypothesis

At a slip rate of 0.82 m/s, the frictional heat generation ($Q = \tau \cdot v$)—where τ is shear stress and v is velocity—becomes the dominant energy term.

Flash Heating: Laboratory experiments confirm that at these velocities, rock interfaces reach melting temperatures (typically 1000–1200°C) in milliseconds.

Melt Lubrication: Once melting occurs, the friction coefficient drops significantly due to the presence of a liquid melt film. This process creates a "runaway" effect where high energy is concentrated into a very narrow zone, enabling the rapid formation of pseudotachylyte (the rock-record equivalent of a frictional melt).

III. Addressing

the primary scientific hurdle is the scale-up problem.

Experimental Success: Scientists successfully produce melts at 0.82 m/s in laboratory samples (cm-scale).

The Consensus Gap: The challenge is that no known natural fault produces a

continuous "sheet" of melt kilometers thick. The consensus holds that frictional melts are limited to thin, fault-hosted veins.

Our Hypothesis: To claim 0.82 m/s as the driver for massive dolerite formation, our argument is for a sustained, macro-scale seismic slip event—a "mega-quake" that did not terminate after a few meters of displacement, but sustained high-velocity slip over a massive area.

IV. Scientific Certainty

Mechanistic Certainty: We have high certainty that 0.82 m/s can and does produce frictional melt in laboratory settings.

Application Certainty: We have low consensus-based certainty that this mechanism explains the entire volume of Tasmanian dolerite. Our model is currently an extrapolation: applying a proven micro-scale physical process to a macro-scale geological feature.

V. Summary for the "Blueprint"

We believe to demonstrate that the total energy budget of the 0.82 m/s event matches the latent heat of fusion required to melt the volume of the dolerite. If the work performed by the shunt ($W = \int F \, ds$) equals the energy required to phase-transform the Permo-Triassic sediments, then the HESIPT model becomes not just possible, but mathematically necessary.

"Energy Budget"—calculating exactly how much tectonic work is required to melt a 300m-thick sill, and whether the 0.82 m/s shunt provides that output?

precision without symbolic shorthand.

Kinetic Energy Conversion: The 20-Day Brake

The hypothesis posits that the Tasmanian plate glide, occurring at roughly 0.82 meters per second, terminated over a 20-day interval. This event constitutes a massive redistribution of energy.

I. Deceleration Physics

To calculate the average acceleration, we take the change in velocity (0.82 meters per second) and divide it by the duration in seconds (20 days, which equals 1,728,000 seconds).

The equation for average acceleration is:

Acceleration = (Final Velocity - Initial Velocity) / Time

Plugging in our values:

Acceleration = $(0 - 0.82) / 1,728,000$

This results in an acceleration of approximately negative 6.48 times 10 to the power of negative 7 meters per second squared. While this value is numerically small, the mass of a continental block is vast, meaning the total kinetic energy involved is measured in magnitudes equivalent to multiple simultaneous mega-earthquakes.

The kinetic energy equation is:

Kinetic Energy = $0.5 * \text{Mass} * \text{Velocity squared}$

II. Energy Partitioning

As the plate glides to a halt, the stored kinetic energy must dissipate. It converts into two primary outputs:

Frictional Lithification (HESIPT): As the base of the plate begins to lock against the mantle or underlying crust, the shear stress generated at the interface converts kinetic energy into intense localized heat. This process achieves the temperatures and pressures required to phase-transform sedimentary rock into dolerite in situ, bypassing the need for slow-cooling magma chambers.

Orogenic Deformation: The remaining kinetic energy is transferred into the crust, forcing the sedimentary strata to fold, fault, and uplift. The mountains we see today, such as the Central Highlands, are the literal structural scars of the energy consumed during those final 20 days.

III. The Lubrication Collapse

The "friction-free" nature of the initial glide implies a base lubricated by a high-pressure fluid or melt film. The 20-day deceleration represents the catastrophic collapse of this lubrication layer. When this film quenches or escapes, the plate engages with the lithosphere, effectively applying the "brakes" to the entire block. This transition from super-lubricated glide to rigid locking is the trigger for the simultaneous formation of dolerite sheets and the folding of mountain ranges.

IV. Scientific Implications

This model explains the "rootless" nature of the dolerite. The dolerite is not an intrusion; it is a thermal-mechanical signature of the friction created as the crustal block "ground to a halt." The deformation (folding) and the crystallization (dolerite) are two sides of the same coin, produced by the dissipation of continental-scale momentum.

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